United States
Department of
Agriculture

Forest Service
Southern Region

Longleaf Pine Management

Forestry Report R8-FR 3
December 1983

Front cover: Longleaf pines on average sites maintained at medium densities by periodic low thinning are capable of growing 550 to 650 board feet per acre per year between age 50 and 60.

METRIC CONVERSIONS

1 inch	2.54 centimeters
1 foot	30.48 centimeters
1 square foot	0.0929 square meter
1 cubic foot	0.0566 cubic meter
1 pound	453.59 grams
1 acre	0.4047 hectare
1 board foot (12 x 12 x 1 inch thick, without bark, 1/4-inch International Scale)	0.00348 cubic meter

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the research efforts and contributions of many individuals, but especially William D. Boyer, Thomas C. Croker, Richard E. Lohrey, and John B. White.

LONGLEAF PINE MANAGEMENT

by

Roger W. Dennington, Softwood Management Specialist
USDA Forest Service
Southern Region
Atlanta, Georgia

Robert M. Farrar, Jr., Principal Mensurationist
USDA Forest Service
Southern Forest Experiment Station
Monticello, Ark.

TABLE OF CONTENTS

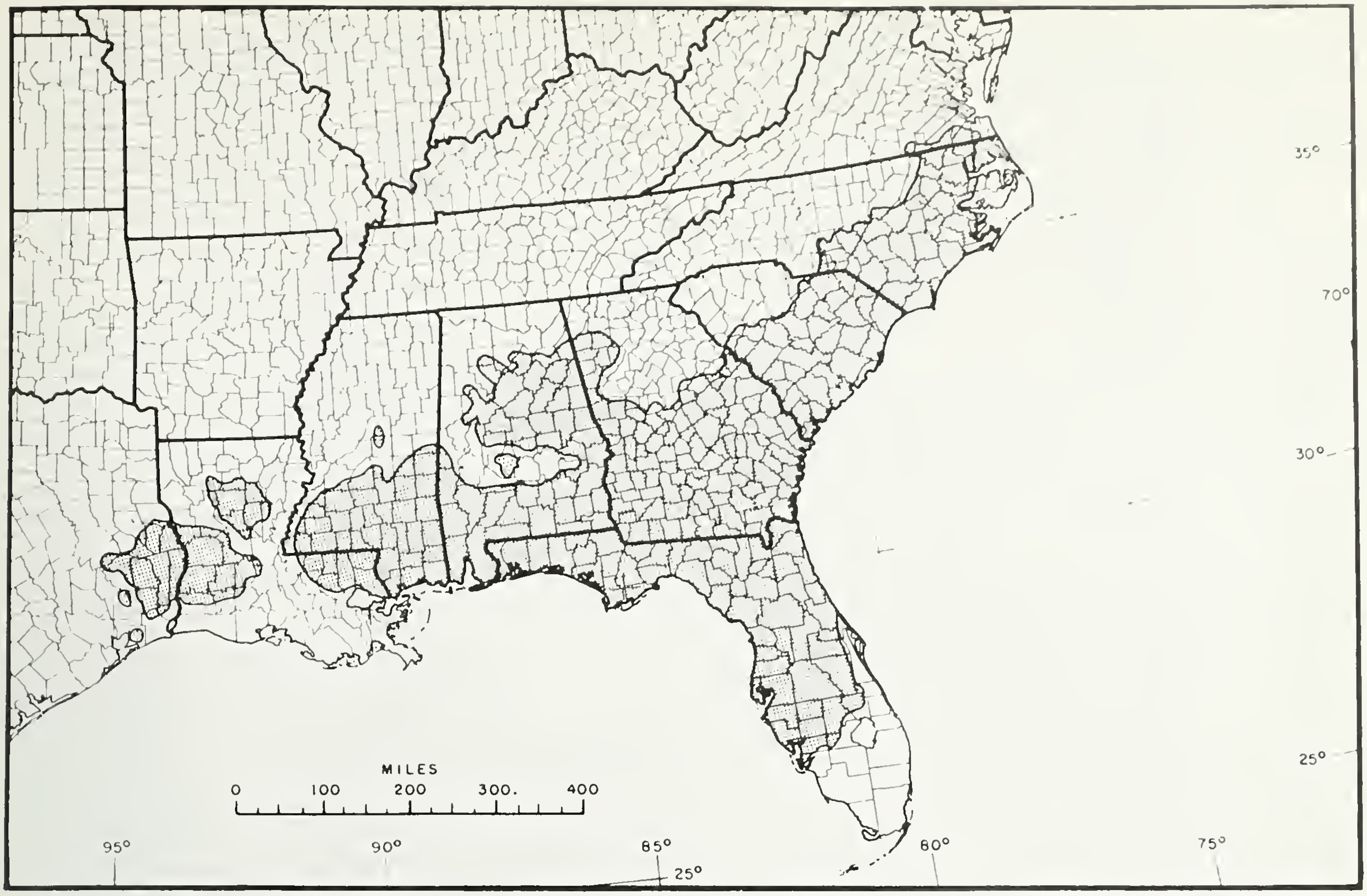

Figure 1. — The botanical range of longleaf pine. *Source: Agriculture Handbook 271*

INTRODUCTION

Early settlers encountered a virgin longleaf pine forest from southeastern Virginia to east Texas (figure 1). Some have estimated the original total acreage to be 50 to 60 million acres. Now that this land is settled, only 5 million acres of longleaf pine remain.

What factors contributed to such a drastic change? Conversion to other uses and species, unfavorable cutting practices, and failure to provide proper regeneration conditions are the principal culprits. But recent research and an array of successful experiences are giving hope that some of the lost ground can be regained for this valuable southern pine species.

Longleaf pine grows well on a variety of sites, but is most often found on sandy soils low in organic matter in the surface portion and medium to strongly acid. Drainage often ranges from good to excessive.

Poorly drained sites are seldom occupied by longleaf because of seed intolerance to flooding and the absence of fire needed to control competing hardwood vegetation. Longleaf grows best in pure, even-aged stands.

Average annual temperatures in the longleaf belt range between 60° and 70°F, with the winter norm over 45° and the summer norm above 75°. Rainfall annually exceeds 55 inches over much of the longleaf range, and nowhere falls below 42 inches. On drier sites, common associate species are bluejack, turkey, blackjack, and sand post oak, while slash and loblolly pines, water oak, southern red oak, sweetgum and dogwood are found on moister sites. During its early development stages, longleaf will not compete well with hardwood brush.

Cones mature in October, after pollination 19 months earlier in March or April. A major regeneration problem is irregular seed production. For instance, during a 20-year period in southern Mississippi, there were two heavy seed crops, six medium, five light, and seven failures or near failures.

Figure 2. — On most sites, proper site preparation, good seedlings, and careful planting ensure successful longleaf pine plantations that often stay 3 to 5 years ahead of natural regeneration. This vigorous stand on a prepared site is in its fifth growing season since planting.

PLANTING

Many foresters have the misconception that longleaf cannot be planted successfully. Perhaps this idea developed over a period of years when inadequate attention was given to the fairly sensitive requirements of the species. Much of the failure in plantations is due to the use of submarginal nursery stock on inadequately prepared planting sites (figure 2). Other shortcomings are the improper care and handling of seedlings between lifting at the nursery and outplanting, as well as improper planting techniques.

Longleaf seedlings do not grow well under woody plant competition. Unlike some pine species, longleaf seldom outgrows its competitors in the early seedling stages. Thus, nearly complete control of competing hardwood is necessary before planting. In addition, volunteer longleaf seedlings on a planting site provide a source of brown-spot disease infection, and heavy brown-spot infection reduces seedling survival and growth.

Combinations or single treatments of clearing, raking, discing, chopping, burning, and herbicides are usually needed before planting to adequately prepare the site. Soil disturbing treatments such as chopping or discing should be performed long enough before planting to allow loose soil to settle and firm up with the summer and fall rains. Planting on unsettled soils often results in fatal soil movement away from or on top of the seedling.

Ideally, bare-root seedlings should have: (1) a root collar diameter of 0.5 inch; (2) numerous 6 to 8-inch lateral roots with evidence of ectomycorrhizal development; (3) a stout tap root 6 to 8-inches long; (4) a winter bud with scales; and (5) abundant, largely-fascicled needles that are free from brown-spot disease. Seedlings with a root-collar diameter of 0.3 inch or less are

generally poor survival risks under adverse conditions.

Machine planting is often superior to hand planting because the larger slit created by the machine provides for better root alignment. Large healthy roots are more difficult to plant correctly with the conventional hand planting bar. Because longleaf seedlings have no stems, planting depth is much more critical than for other southern pine species. The planted longleaf seedling should be positioned with its root collar at or slightly (no more than 1 inch) below the ground line so that the seedling bud will be exposed when the soil has fully settled 2 to 3 months later.

Some minor adjustments must occasionally be made in planting depth to offset the anticipated movement of soil away from or onto the seedling after planting. This is a risky proposition, however, and should generally be avoided by restricting planting to soils that have settled.

Even though seedling cost is the cheapest part of the reforestation process, meticulous attention must be given to the care, handling, and planting procedures. Longleaf seedlings are more sensitive to abusive treatment than other species. Do not allow seedlings to dry, heat, or freeze during shipment, storage, or planting. Seedlings should be stored in a cool shaded place or, preferably, refrigerated at about 35°F for no longer than 2 to 3 weeks. Planting dates vary, but generally range from December to March, with the first two months slightly better.

Availability of small-product markets, expected survival, and landowner objectives will determine planting rates in the plantation. Initially, 4- by 9-foot spacing or about 1,200 seedlings per acre is recommended until successful experience shows planting density can be reduced. A range of 800 to 900 seedlings per acre surviving after the first growing season is a good goal.

In North Carolina, containerized seedlings have been successfully planted in the spring and summer. This not only permitted extension of the planting season, but also resulted in a mean survival rate of 80 percent. These seedlings were also significantly taller than bare-root seedling after 3 growing seasons. Burning 3 to 4 months before summer planting of containerized seedlings may later result in lethal soil temperatures at the root collar due to the presence of black ash.

DIRECT SEEDING

For many, direct seeding is the most cost-effective regeneration method when adequate seed trees are not available. But it's risky. Many acres have been successfully and economically established with direct seeding. Likewise, many seedings have been lost due to adverse weather, animals, and failure to observe some basic practices.

Site preparation — by burning, chemical, or mechanical means — must bring the woody competition well under control and expose at least 50 percent of the mineral soil. Row and spot seeding do not require as much exposed mineral soil, but woody competition should be in check before sowing.

Broadcast, row, and spot seeding need a minimum of 13,000, 6,800, and 5,700 repellent-treated viable seeds per acre, respectively. Seed lots used for direct seeding should have germination percentages of 80 or better. Cleaned, dewinged seeds average 4,500 per pound. The repellent coating generally will increase the weight by 8 to 10 percent. Furrow or row seeding requires one seed per 9 to 12 inches of furrow; seed spots should have five to six seeds.

Direct seeding should not be used on poorly-drained sites or sites with high water tables. Water standing in a furrow or on the surface will result in quick mortality to newly germinated seedlings. Other risky sites for direct seeding are eroded sites, where seeds are easily washed away, and coarse, sandy topsoils with rapidly drying surfaces. Tree squirrels are often a problem because approved repellent seed coatings are not effective against them.

Normally, seed should be sown in the fall when soil moisture is adequate and maximum daytime temperatures drop below 85°F. Sites that are subject to frost heaving and clipping of seedlings by rabbits are an exception and should be sown in the late winter. Longleaf seeds do not require cold stratification before sowing.

NATURAL REGENERATION

Like all of the original stands, longleaf can be reproduced through natural regeneration methods. A recommended shelterwood system has been developed and may be the best for many small ownerships because it is less expensive than clearcut, site prepare, and plant methods (figure 3). Any natural regeneration method for longleaf pine must provide at least four essential elements: (1) sufficient desirable parent trees, well distributed so that they provide an adequate supply of seed throughout the regeneration area; (2) midstory, understory, and seedbed conditions favorable for the establishment, survival, and growth of seedlings; (3) protection from livestock, wildfire, brown-spot disease, and other hazards; and (4) complete release from overstory and brush competition after adequate stocking has been secured.

The shelterwood method works best if applied after steps have been taken to prepare the stand for regeneration before the harvest cut. If overstory density exceeds 70 to 80 square feet of basal area per acre, a preparatory cut should be made. This cut should be made about

Figure 3. — A shelterwood system, properly applied, is the most reliable regeneration method for naturally reproducing longleaf pine stands. The seed cut, reducing the basal area to about 30 square feet per acre, has been made in the above parent stand.

5 years in advance of the seed cut, leaving 60 square feet of basal area on the poorest sites and 70 square feet on the better sites. The preparatory cut is essentially a thinning, mostly from below, which leaves the largest trees of good quality with ample room to enlarge their crowns. Hardwood competition should be controlled by prescribed burning, chemicals, or a combination of both before the seed cut or promptly after.

The seed cut should leave 25 to 30 square feet of basal area per acre of seed trees showing signs of fruitfulness. Those trees should be evenly distributed over the area, more than 30 years old, 10 inches or more in d.b.h., and above average in height, form class, and volume. Several years may elapse between the seed cut and the establishment of adequate regeneration. But this period isn't totally unproductive. Parent trees generally experience accelerated growth that may equal as much as half or more of the per acre growth occurring before the cut. During this period, hardwoods should be kept under control by timely prescribed burns.

Also, after the seed cut, an annual forecast of seed crops should be made for the purpose of timing the final seedbed preparation treatment before seedfall. Counting conelets in the spring with the aid of binoculars will give good estimates of the current year's cone crop, and a count of flowers at the same time may give an indication of the potential cone crop 18 months hence. These counts should be made in late April or early May, just before female flowers are obscured by new foliage.

The amount of seed necessary to ensure a new stand depends on the condition of the seedbed, predator pressure, the soil, understory conditions and existing seedling stocking. Ideally, at least 50,000 seeds per acre are

Figure 4. — Reproduction from a shelterwood system is capable of rapid development once the parent stand is removed. This excellent stand of saplings is in its sixth growing season since overstory removal.

needed on a well-prepared seedbed to get a good stand of seedlings established. This requires roughly 1,000 cones per acre or 35 to 50 cones per seed tree. Timing a prescribed burn or light mechanical scarification up to 3 months before seedfall (normally mid-October through November) is strongly recommended.

Once an adequate seedling stand is established, the overstory should be harvested, ideally at seedling age 2, but before many seedlings begin height growth (figure 4). The usual criterion for an adequate seedling stand is 6,000 or more 1-year-old seedlings per acre. This number will absorb logging mortality of up to half the stand and still provide enough survivors that the superior 10 to 20 percent of the seedling stand will provide about 500 crop seedlings per acre. Regardless of age, rapid height growth does not start until the seedlings are at about 1 inch in diameter at the groundline.

TREE IMPROVEMENT

No single seed source can be recommended for all of the South. Generally, local sources are the best choices within the five collection zones (figure 5). Seed from the north extremity of Zone IV performed poorly when moved south, as did seed from Zone V when moved out of the Florida peninsula. Evidence indicates that movement of seed anywhere within Zone II is acceptable.

There are about 443 acres of first generation longleaf pine seed orchards across the South. When second and third generation orchards reach full production, they should produce enough superior seed to meet demand.

Most tree improvement work is being concentrated on two related problems: breeding for brown-spot dis-

Figure 5. — The five seed collection and planting zones for longleaf pine.

ease resistance and fast initial height growth. Seedling orchards, where open-pollinated seed from many trees are planted and then rogued based upon selected characteristics, appear to have promise. Improved seed lots not needed for nursery production may be used effectively in direct seeding projects by mixing them with woods-run seed. Presumably, some crop trees in the resultant stand should be the improved types.

Seed trees selected in the shelterwood regeneration system should not only be above average in fruitfulness, but also should be of the highest apparent genetic quality that's available. In wild stands this probably would do little more than maintain the genetic status quo, but these native genotypes may be as well as or better suited to the environment as non-natives.

GROWTH AND YIELD

Longleaf pine stands are generally slow starters, but once they reach sapling size, well-stocked stands compare favorably with other southern pines and may outgrow them on some sites. The average site index for natural longleaf stands is about 70 feet at index age 50 years. For more detailed growth and yield information and examples of utility, see the publications by Lohrey, Lohrey and Bailey, and Farrar in the Suggested Reading list.

Planted Stands

This information is based on thinned and unthinned plantations in the West Gulf area. These plantations originated on unprepared planting sites that were largely free of competing woody vegetation.

In table 1, for unthinned plantations on site index 45 (index age = 25 years), the number of trees declines with age due to mortality, while basal area and volume increase due to diameter and height growth of surviving stems. Yields are highest for the oldest age and

Table 1 — Predicted number of trees, basal area, and volume yield per acre for unthinned longleaf plantations at given ages and densities starting at age 15 on cutover sites in the West Gulf, site index = 45 feet.[1]

	Trees per acre at age 15 years					
Age	**100**	**200**	**300**	**400**	**500**	**600**
YEARS	*Trees per acre (no.)**					
15	100	200	300	400	500	600
20	96	190	282	372	460	546
25	91	176	255	330	401	468
30	86	163	232	295	351	402
35	82	153	213	266	312	352
40	79	144	199	244	282	313
	*Total basal area (ft^2)**					
15	11.3	15.4	17.9	19.5	21.4	24.4
20	23.2	35.5	44.7	52.1	58.3	63.7
25	31.5	49.6	63.4	74.9	84.7	93.3
30	39.6	63.2	81.4	96.3	108.6	119.3
35	49.4	79.7	102.4	120.8	136.0	148.6
40	62.5	101.0	130.4	153.0	171.3	185.8
	Yield (total ft^3, o.b.)†					
15	185	249	287	312	342	389
20	490	741	928	1,078	1,205	1,314
25	779	1,213	1,542	1,813	2,046	2,248
30	1,086	1,716	2,195	2,588	2,911	3,189
35	1,458	2,328	2,971	3,493	3,923	4,278
40	1,948	3,110	3,994	4,669	5,214	5,642
	Periodic annual growth (total ft^3, o.b.)†					
15-20	61	98	128	153	173	185
20-25	58	94	123	147	168	187
25-30	61	101	131	155	173	188
30-35	74	122	155	181	202	218
35-40	98	156	205	235	258	273

[1] Index age = 25 years. Corresponding site index for index age 50 is 71 feet.
* All trees with d.b.h. >0.5 inch.
† All trees with d.b.h. >0.5 inch, entire stem outside bark.
Source: Adapted from Lohrey and Bailey (1977)

highest initial density. Yields are low at age 20, but more than double by age 30 and nearly double again by age 40.

Periodic and mean annual increment (PAI and MAI) both increase with age and initial density. PAI is highest between age 35 and 40 and MAI is highest at age 40. The PAI varies from about 0.7 cord per acre per year between ages 15 and 30 for 100 initial trees per acre, to about 3 cords between ages 35 and 40 for 600 trees per acre. The yields at age 40 vary from about 22 cords at the lowest initial density up to about 63 cords for the highest. The MAI would be about 0.6 and 1.6 cords per acre per year, respectively.

Data for thinned plantations, also taken from West

Table 2 — Predicted stand volume and periodic annual growth per acre for thinned longleaf plantations at given ages and residual basal areas on cutover sites in the West Gulf, site index = 45 feet.[1]

	Total residual basal area per acre (ft^2)					
Age	**20**	**40**	**60**	**80**	**100**	**120**
YEARS	*Stand volume, (total ft^3, o.b.)**					
20	409	834	1,266	1,702	2,142	2,584
25	472	963	1,461	1,965	2,472	2,983
30	519	1,059	1,608	2,162	2,720	3,282
35	556	1,134	1,722	2,315	2,913	3,514
40	585	1,194	1,812	2,437	3,066	3,699
45	609	1,242	1,886	2,536	3,190	3,849
	*Periodic annual growth, (total ft^3, o.b.)**					
20-25	88	134	167	192	212	227
25-30	75	115	143	164	180	192
30-35	66	100	125	143	156	166
35-40	58	89	110	126	138	146
40-45	52	80	99	113	123	130
	Stand volume, (board feet, Int. ¼-inch rule)†					
20	178	222	253	277	297	315
25	708	883	1,004	1,099	1,180	1,250
30	1,777	2,214	2,518	2,759	2,961	3,137
35	3,429	4,272	4,858	5,322	5,712	6,052
40	5,613	6,992	7,951	8,711	9,349	9,906
45	8,234	10,258	11,655	12,779	13,716	14,532
	Periodic annual growth, (board feet, Int. ¼-inch rule)†					
20-25	134	158	174	186	196	205
25-30	272	320	352	377	397	414
30-35	425	500	529	586	617	643
35-40	572	670	734	783	823	857
40-45	699	816	892	950	997	1,037

[1] Index = 25 years. Corresponding site index for index age 50 is 71 feet.
* All trees with d.b.h. >0.5 inch, entire stem outside bark.
† All trees with d.b.h. >9.5 inches to a 8-inch top d.o.b.
Source: Adapted from Lohrey (1979)

Gulf stands, show excellent annual board-foot growth after about age 30 for site index 45 (table 2). Board-foot growth increases as stand age and residual density increase and, in each case, board-foot growth is highest between ages 40 and 45. For all residual densities, the growth rate exceeds 500 board feet per acre per year beyond about age 30.

Cubic-foot growth increases with density, but decreases with age. It is always highest between ages 20 and 25. This growth rate varies from a low of about 0.6 cord per acre per year between ages 40 and 45 for 20 square feet to about 2.5 cords between ages 20 and 25 for 120 square feet. The cubic-foot volumes for thinned plantations (table 2) and unthinned plantations (table 1) under similar conditions of age, site index, and basal area are nearly equal.

Information in table 2 can be used to estimate the volume that might be cut periodically from a stand on

Table 3 — Simulated thinning regime and resulting volume yield per acre for a longleaf plantation on site index 45.[1]

Age	Before-cut		After-cut		Cut	
	Basal area	Total volume	Basal area	Total volume	Basal area	Total volume
yrs	ft^2	ft^3, *o.b.*	ft^2	ft^3, *o.b.*	ft^2	ft^3, *o.b.*
30	120	3,282	80	2,162	40	1,120
35	—	2,877 (=2,162+143×5)	80	2,315	—	562
40	—	2,945 (=2,315+126×5)	80	2,437	—	508
45	—	3,002 (=2,437+113×5)	0	0	—	3,002 Yield = 5,192

[1] Using data from table 2.

site index 45 and the total yield over a rotation. Assume, for example, a 30-year-old plantation with 120 square feet of basal area. The objective is to thin it at age 30 and every 5 years thereafter to leave 80 square feet, and to harvest it at age 45. Using the cubic-foot volumes and growth rates in table 2, obtain the before-cut, after-cut, and cut volumes shown in table 3. The after-cut volumes are specified by the residual basal area desired, and the before-cut volumes are calculated by adding the residual volume at age A to the growth between ages A and A+5. The cut volumes are obtained by subtracting the after-cut volume from the before-cut volume at a given age. The yield is obtained by summing the periodic cuts, including the final harvest, to obtain 5,192 cubic feet or about 58 cords. The MAI would be about 1.3 cords per acre per year.

Thinned Even-aged Natural Stands

Information on thinned natural stands of longleaf comes from the East Gulf area. Generally, thinned natural stands have somewhat more predicted cubic-foot volume than thinned plantations for comparable conditions of age, site index, and density, particularly after age 20 (table 4). The reverse is indicated when considering board-foot volumes — the natural stands lag behind the plantations. Probably, the major reason is that plantations usually have fewer initial trees per acre and less hardwood competition than natural stands. This results in more rapid diameter growth and earlier development of sawtimber volumes. Natural stands tend to have higher initial densities and more competition, resulting in slower diameter growth and later development of sawtimber volumes. This suggests that natural stands will require longer rotations than planted stands to obtain comparable sawtimber volumes, unless non-commercial thinnings are imposed to enhance early sawtimber production.

Periodic annual increment (PAI) in board feet for thinned natural stands on site index 70 (index age = 50 years) increases with age and tends to be greatest at low residual densities at early ages and greatest at high densities at older ages (table 4). Board-foot growth peaks between ages 40 and 50 for lower basal areas (40 or less square feet), but is greatest between ages 50 and 60 for the higher basal areas. Board-foot PAI exceeds 500 fbm only beyond age 40 and for residual basal areas of 60 square feet or greater. As in thinned plantations, cubic-foot growth increases with residual density and is greatest between ages 20 and 25 in all cases shown. It varies from about 0.6 cord per acre per year between ages 50 and 60 for 20 residual square feet to about 3.0 cords between ages 20 and 30 for 120 square feet.

Estimated total stand yield over a rotation can be determined from table 4. Assume a stand on site index 70 with 120 square feet of basal area at age 30. The objective is to thin the stand at age 30 and 40 to leave 80 square feet and harvest it at age 50. Using cubic-foot volumes from table 4, the cut values predicted in table 5 would give a total yield of 6,392 cubic feet or about 71 cords. The mean annual increment (MAI) would be about 1.4 cords per acre per year. The predicted yield

Table 4 — Predicted stand volume and periodic annual growth per acre for thinned natural longleaf stands at given ages and residual basal areas in the East Gulf, Site index = 70 feet[1].

	Total residual basal area per acre (ft^2)					
Age	**20**	**40**	**60**	**80**	**100**	**120**
YEARS	*Stand volume, (total ft^3, o.b.)**					
20	409	815	1,222	1,628	2,035	2,441
30	545	1,103	1,660	2,217	2,775	3,332
40	625	1,273	1,921	2,569	3,217	3,866
50	676	1,382	2,089	2,796	3,503	4,211
60	711	1,457	2,204	2,952	3,700	4,448
	*Periodic annual growth, (total ft^3, o.b.)**					
20-30	113	163	199	226	248	266
30-40	83	122	150	170	186	199
40-50	65	97	119	136	148	157
50-60	53	80	98	112	122	130
	Stand volume, (board feet, Int. ¼-inch rule)†					
20	20	30	30	30	30	30
30	370	550	630	620	580	520
40	1,500	2,540	3,160	3,420	3,390	3,180
50	2,650	4,950	6,820	8,160	8,950	9,190
60	3,340	6,520	9,450	12,050	14,190	15,750
	Periodic annual growth, (board feet, Int. ¼-inch rule)†					
20-30	60	58	50	41	34	28
30-40	229	281	277	253	220	185
40-50	312	461	542	573	567	533
50-60	283	442	561	654	722	763

[1] Index age = 50 years.
* All trees with d.b.h. > 0.5 inch, entire stem outside bark above a 0.2-foot stump.
† Trees with d.b.h. > 9.5 inches to a 5-inch top d.i.b. and above a 1-foot stump.
Source: Adapted from Farrar (1979)

Table 5 — Simulated thinning regime and resulting volume yield per acre for a natural longleaf pine stand on site index 70.[1]

	Before-cut		After-cut		Cut	
Age	**Basal area**	**Total volume**	**Basal area**	**Total volume**	**Basal area**	**Total volume**
yrs	*ft^2*	*ft^3, o.b.*	*ft^2*	*ft^3, o.b.*	*ft^2*	*ft^3, o.b.*
30	120	3,332	80	2,217	40	1,115
40	—	3,917 (=2,217 + 170 × 10)	80	2,569	—	1,348
50	—	3,929 (=2,569 + 136 × 10)	0	0	—	3,929 Yield = 6,392

[1] Using data from table 4.

and MAI for the thinned natural stand were greater than those for the thinned plantation example, not only because the natural stand rotation was 5 years longer, but also because the predicted PAI rates from the natural stand were somewhat higher.

Many other simulations of thinning regimes are possible for planted and natural stands using the sources for tables 2 and 4. The predicted effect of different thinning intervals, residual basal area schedules, and rotation lengths on volume production can be evaluated for a variety of site indices. However, they are beyond the scope of the brief tables presented here and will require use of information in the publications by Lohrey and Farrar in the Suggested Reading list.

DAMAGING INFLUENCES

Insects

Compared to most other commercial tree species, longleaf has few serious insect pests. Bark beetles, including the southern pine beetle, Ips engraver beetle, and the black turpentine beetle are the most destructive, but generally do not present serious problems.

The southern pine beetle is of the most concern because it attacks relatively healthy stands of pine when the beetle populations reach epidemic proportions. Prevention is the most realistic way to hold down timber losses. Maintaining stands of healthy, fast-growing trees, thinning very dense stands, harvesting overmature stands, and using harvesting practices that minimize damage to residual trees during logging are the most efficient prevention measures.

Black turpentine beetles are attracted to trees damaged in logging or stressed by climatic factors, while the Ips engraver beetle normally will attack only extremely stressed trees such as those struck by lightning.

West of the Mississippi River, the Texas leaf-cutting ant is a problem in local areas. This insect inhabits drier sandy sites and can defoliate seedlings within 300 feet of its colonies.

Diseases

Brown-spot needle blight is the most destructive disease of longleaf pine. This fungus attacks seedlings while they are in the grass stage. Not only will the disease delay the initiation of height growth, but may kill the seedling after the third year of heavy defoliation. Using seed from known brown-spot disease resistant sources is a good preventive measure.

Prescribed fire is the only practical means of controlling this disease on established seedlings. Before using fire, a survey of the stand should be made to determine the degree of infection and if seedlings are large enough to survive the fire. About 100 milacre plots are required to make a diagnosis for the stand, and examination should be confined to the best crop seedling on each plot. If 20 percent or more of all of the cumulative foliage on the sampled crop seedlings is infected, a burn should be considered.

Timing is important. One study found that when 40 percent or more of the needle surface was infected, mortality from the fire exceeded survival. Data from the same study also suggested that seedlings are susceptible or resistant to mortality from fire according to four root collar size classes: (1) susceptible grass stage (less than 0.3 inch), (2) resistant grass stage (0.3 to 0.7 inch), (3) susceptible height-growth stage (0.8 to 1.4 inches), and (4) resistant height-growth stage (1.5 inches and larger).

Annosus root rot, pitch canker, and fusiform rust diseases occasionally infect longleaf pine, but it's more resistant than other southern pines, and damage is minor.

Animals

Livestock — especially hogs — and longleaf pine seedlings are not compatible. Hogs are attracted to the succulent cortex of the main taproot and can do considerable damage to young stands by rooting up the seedlings. In spite of considerable improvement in eliminating the open range grazing of yesteryear, hogs are still a problem in some local areas.

Many plantations have been lost because of unmanaged grazing of other livestock. Not only are seedlings trampled and sometimes grazed, but cattle grazing may also reduce the amount of grassy fuels needed to support an effective prescribed fire for controlling brown-spot disease. The best policy is to keep cattle completely out of young longleaf stands until the saplings average 8 to 10 feet in height. Controlled grazing in increasingly moderate amounts could be permitted after this point.

Pocket gophers are a problem in some areas, gnawing roots and pulling small seedlings into the underground burrows. Traps and poison are effective control measures.

Figure 6. — Dense, green needles protect the bud of healthy longleaf pine seedlings from most surface fires.

FIRE MANAGEMENT

Fire was the natural architect of the original forest. Ecologists classify longleaf pine as a sub-climax type, meaning that the species is maintained by periodic fire. Longleaf seedlings, endowed by nature with thick bark and a thick concentration of needles around the bud (figure 6), are resistant to fire damage and find a compatible home on soils where the ground vegetation consists of coarse, flammable grasses. Prescribed fire is a tool that must be included in the management strategies of longleaf (figure 7).

Prescribed fire is the only cost-effective way to control brown-spot needle disease. Hardwoods and heavy accumulations of fuel that can feed a hot wildfire can also be kept under control by timely prescribed fires. Seedbeds for natural regeneration are also prepared most economically by fire.

This was illustrated in the summer and fall of 1947 by a planned burn in south Alabama. Anticipating a bumper seed crop, 26,010 cutover acres with scattered longleaf seed trees were burned between August and the end of October. Three months after seedfall, the burned area had an average stocking of 13,200 seed-

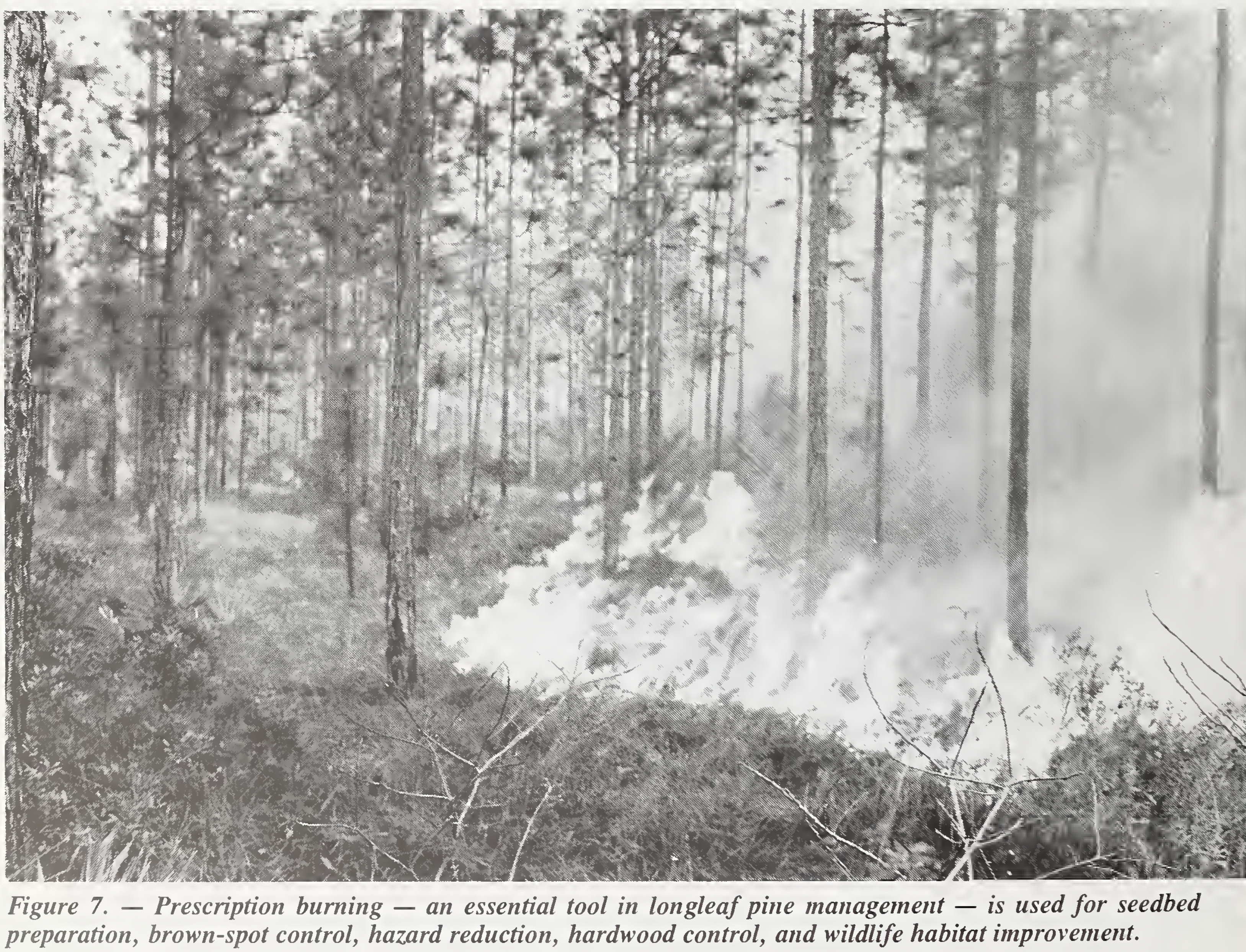

Figure 7. — Prescription burning — an essential tool in longleaf pine management — is used for seedbed preparation, brown-spot control, hazard reduction, hardwood control, and wildlife habitat improvement.

lings per acre with a distribution of 1,000 or more per acre on 93 percent of the area.

Two other studies in Louisiana and Alabama showed that annual and biennial fire applied around May 1 stimulated the height growth of longleaf seedlings in the grass stage as well as helped control brown-spot needle disease on infected seedlings.

In spite of the advantages, fire must be used carefully. If seedlings are growing in large accumulations of needle litter, heavily-infected with brown-spot disease, and small in root collar diameter, they will often suffer well over 50 percent mortality from fire. Furthermore, seedlings between 1/2 to 3 feet in height are vulnerable to fire.

But, under proper conditions in the seedling stages, longleaf survives and even thrives on fire. Therefore, some managers are selecting longleaf over other species when regenerating stands in high fire-risk areas.

MANAGEMENT OPPORTUNITIES

Longleaf timber owners should consider managing for and marketing poles and piling. Historically, pole stumpage is about 30 to 40 percent above the price of sawlog stumpage. Longleaf is the preferred species of southern pine for poles and pilings (figure 8). Even-aged, well-stocked stands grow the most linear feet of poles because there are more trees per acre and trees in dense stands have less taper.

Rarely should longleaf be grown exclusively for pulpwood products. Because of its slower early growth, its greatest economic returns come from larger products grown on longer rotations, such as sawtimber, poles, piling, and veneer logs. Rotation lengths of around 60 years will produce high quality products on average sites of 70 to 80. If, however, the process of regenerating a new stand consistently takes longer than 5 years, then 70- to 80-year rotations should be considered.

Because longleaf pine readily expresses dominance, precommercial thinning is rarely needed to prevent stagnation. Use this treatment only if dominant saplings exceed 1,500 per acre and early sawlog production is an objective. Residual densities after precommercial thinning probably should be 500 to 700 trees per acre at about the age of 10 years. Commercial thinnings should be influenced by product and management objectives and almost always should be from below to favor crop trees. If poles are the objective, thinnings should be lighter than usual and concentrate more on leaving the best pole candidates and less on spacing. If naval stores and large sawtimber are desired, then thinnings should be heavier to encourage the development of a fuller crown and larger stem diameter.

A rule-of-thumb when sawtimber is the objective is to thin to a basal area (BA) density equal to the site index (base age 50) plus the age, minus 40. Thus, a 35-year-old stand with a site index of 80 would be thinned to 75 BA per acre.

Up through about age 60, this rule is comparable to another common rule: leave 57 percent of the normal basal area (see USDA Miscellaneous Publication 50 under "Suggested Reading"). More specifically, use Farrar's stand volume and growth predictors to compare alternative thinning regimes and pick the one that best meets the management objectives.

Wildlife and range management can easily coexist with longleaf wood production objectives. A schedule for burning on a 3-year cycle will retard hardwood brush growth and favor legumes and other herbaceous plants that offer an ideal habitat for bobwhite quail. Other favorite game species such as white-tailed deer and wild turkey also benefit by the burning and thinning practices needed for good stand management.

Because of the heavy grass cover normally occurring over much of the longleaf range, cattle grazing is a frequent combination use of the forest. Only during the stand regeneration and early seedling-sapling stages is grazing incompatible with timber management objectives. Cattle should be excluded from longleaf stands in these stages.

The gum naval stores industry uses longleaf oleoresin to distill into a variety of products. This use has dropped dramatically in the last 20 years, even though research has developed methods that are considerably less destructive to the tree boles, which are subsequently used for other products.

Figure 8. — Well-stocked stands of 40 to 80-year-old longleaf pine are a prime source of valuable utility poles.

SUGGESTED READING

Croker, Thomas C., Jr.; Boyer, William D. Regenerating longleaf pine naturally. Research Paper SO-105. New Orleans, LA; U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1975. 21 p.

Farrar, Robert M., Jr. Growth and yield predictions for thinned stands of even-aged natural longleaf pine. Research Paper SO-156. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1979. 78 p.

Fowells, H. A. (comp.) Silvics of forest trees of the United States. Agriculture Handbook 271. Washington, D.C.: U.S. Department of Agriculture; 1965. 762 p.

Guldin, Richard W. Container-grown longleaf pine regeneration costs in the sandhills. Southern Journal of Applied Forestry, 6(1): 33-39. 1982.

Lohrey, Richard E. Predicted growth of longleaf pine planted on cutover forest sites in the West Gulf. In: Proceedings, Longleaf Pine Workshop, October 1978, Mobile, AL., Technical Publication SA-TP 3. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry; 1979. p. 54-64.

Lohrey, Richard E.; Bailey, Robert L. Yield tables and stand structure for unthinned longleaf pine plantations in Louisiana and Texas. Research Paper SO-133. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1977. 53 p.

Mann, W. F., Jr. Direct-seeding longleaf pine. Research Paper SO-57. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1970 26 p.

Maple William R. Mortality of longleaf pine seedlings following a winter burn against brown-spot needle blight. Research Note SO-195. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1975. 3 p.

U.S. Department of Agriculture. Volume, yield, and stand tables for second-growth southern pines. Miscellaneous Publication 50. Washington, D.C.: U.S. Department of Agriculture; revised 1976. 202 p.

Well managed longleaf pine forests provide both economic and aesthetic benefits.